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THE IMPACT OF LEARNING STATIONS STRATEGY ON DEVELOPING SCIENTIFIC CONCEPTS OF LIFE AND ENVIRONMENT IN EARLY CHILDHOOD SCIENCE EDUCATION

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Abstract. *Science education is fundamental to shaping how children perceive the world and cultivate their initial scientific reasoning. This study examined the impact of the "Learning Stations Strategy" on developing scientific concepts of life and the environment among young learners. Utilizing a quasi-experimental approach, the study involved 64 kindergarteners from Hofuf, Al-Ahsa, Saudi Arabia, divided into experimental and control groups. After consulting with experts to define age-appropriate scientific concepts, an educational unit was crafted around the Learning Stations Strategy. These stations engaged children through hands-on tasks, experiments, observational activities, and guided reflections. To measure progress, a specialized "Scientific Concepts Test of Life and Environment" was administered before and after the intervention. The findings demonstrated statistically significant gains favoring the experimental group, highlighting the strategy's success. Specifically, children participating in the learning stations showed a deeper grasp of life concepts-such as distinguishing between living and non-living things, identifying basic survival needs, and understanding growth, biological functions, and diversity. Furthermore, there was improvement in environmental awareness, including the recognition of natural components, resource utility, ecosystems, environmental stewardship, and the basics of pollution. These findings suggest that moving away from teacher-centered teaching toward more interactive, station-based learning can enhance children's curiosity and understanding.*

Keywords: *science education, learning stations strategy, scientific concepts, life concepts, kindergarten children.*

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Introduction

The landscape of early childhood science education has evolved significantly, moving from a mere elective enrichment to a vital pillar of holistic development. Current research emphasizes that young children are inherently driven to make sense of their world, actively building their own scientific frameworks through daily environmental interactions (Ravanis, 2022). Within this context, the goal of early science exposure isn't simply the delivery of formal facts, but rather the cultivation of an enduring curiosity and a capacity for reasoning and exploration that serves as a foundation for their entire educational journey (Delserieys & Kampeza, 2025).

Today, science education in the early years is far more than just a subject; it is a vital thread woven into the fabric of a child's cognitive, linguistic, and social-emotional growth. Studies indicate that when we involve young learners in purposeful scientific experiences, we help them sharpen essential tools like observation, classification, and reasoning skills that serve as the bedrock for their future academic success (Larimore, 2020). These learning moments truly resonate when they are tailored to a child's developmental stage and remain open-ended, rooted in their daily lives. Such an approach empowers children to navigate scientific concepts at their own rhythm, making discoveries that are both personally relevant and deeply lasting (Raven & Wenner, 2023).

Even with this growing appreciation, many early childhood environments still struggle to weave science into their daily routines in a consistent and meaningful way. Research suggests that science activities often remain isolated or secondary in preschool classrooms, which unfortunately limits the opportunities for children to build the solid conceptual groundwork needed for their future education (Ravanis, 2022). However, when science is placed at the heart of early learning, intertwined with inquiry, exploration, and the child's own initiative, it transforms into a vibrant landscape for growth. This

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integrated approach honors a child's natural instinct to question, observe, and make sense of the world, turning everyday curiosity into a powerful engine for learning (Raven & Wenner, 2023).

The theoretical and practical importance of early childhood science education is further supported by research emphasizing children's agency, participation, and representation in learning. Contemporary studies stress that young learners construct scientific understanding through multiple modes of engagement, including hands-on exploration, dialogue, and interaction with materials (Henriksson et al., 2024). In parallel, recent work highlights the role of teachers' pedagogical choices and professional development in shaping high-quality science experiences, particularly when innovative and adaptive approaches are employed (Chen et al., 2025). Such perspectives position children as active participants in science learning rather than passive recipients of information and underscore the need for rich learning environments that encourage experimentation, reflection, and discovery (Zourmpakis et al., 2022).

Research has shown that even before formal teaching begins, preschool-aged children display observable knowledge about scientific content, and this early science knowledge tends to develop significantly over the preschool year when supported through thoughtful educational experiences (Sarkowi et al., 2023).

Supporting children's scientific concept formation in early childhood involves more than introducing facts; it requires creating opportunities for children to engage in active exploration, observation, and discussion. The literature emphasizes that young learners construct scientific concepts through a combination of sensory experiences, manipulation of materials, and reflective dialogue with peers and teachers (Priadi, 2024). In this view, scientific concepts are understood not as static pieces of information but as organizing structures that children build and revise as they interact with their environment (Efriani et al., 2023).

The central role of science in early childhood is also manifested in the ways children make sense of cause-and-effect relationships and classify objects and events (Ioannou et al., 2023). When children are encouraged to observe closely, make predictions, and test their ideas, they begin to form conceptual networks that tie together their observations and explanations. These experiences lay the foundation for more formal scientific reasoning in later years, highlighting how early engagement with scientific concepts contributes significantly to children's cognitive development (Acharibasam & McVittie, 2023).

Importantly, studies specific to early childhood contexts indicate that structured yet playful science activities help bridge the gap between children's intuitive ideas and more scientific ways of thinking (Siry et al., 2023). Activities that integrate real objects, natural materials, and opportunities for guided inquiry help children refine their mental representations of scientific phenomena and build deeper, more coherent conceptual understanding. Such pedagogical practices reflect an understanding of young children as active constructors of knowledge, rather than passive recipients of taught content (Uludag, 2023).

Focusing on life and environmental concepts in early childhood science education is widely supported in the literature, as these concepts are closely connected to children's everyday experiences and natural curiosity about the living world. Concepts related to living things, their needs, growth, and diversity help young children make sense of the biological aspects of their surroundings, while environmental concepts foster early awareness of nature, resources, and human-environment relationships (Chen et al., 2024). Research has suggested that engaging children with such concepts at an early age contributes to the development of naturalist intelligence and supports children's ability to observe, classify, and care for living organisms in meaningful ways (Henriksson et al., 2025; Priadi & Fatria, 2024).

Life and environmental concepts are also strongly linked to education for sustainable development in early childhood. When children are exposed to ideas about caring for the environment, using natural resources responsibly, and understanding the impact of human actions on nature, they begin to form values and attitudes that support sustainability. Studies conducted in kindergarten contexts indicate that learning environments-particularly outdoor and nature-based settings-play a significant role in helping children connect abstract environmental ideas to concrete experiences, making learning more authentic and impactful (El-Aasar et al., 2024; Wiik et al., 2026).

In addition, research highlights the importance of extending science learning beyond the formal classroom to include out-of-school and informal learning environments. Parents' perspectives on early childhood science programs reveal that activities related to life and environmental concepts become more meaningful when children interact directly with natural settings, plants, animals, and environmental phenomena (Ramulumo & Shabalala, 2025; Uludag, 2023). These experiences support children's understanding of how living things interact with their environments and help bridge the gap between scientific concepts and real-life contexts.

From a broader theoretical perspective, contemporary scholarship in early childhood science education emphasizes that life and environmental concepts serve as foundational domains through which children begin

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to understand complex scientific ideas later in schooling (Morais et al., 2026). Reviews of research themes in early childhood science education stress that these concepts are central to developing inquiry skills, environmental awareness, and scientific reasoning when introduced through developmentally appropriate and interactive approaches (Siry et al., 2023). Interactive and participatory methodologies, in particular, have been shown to enhance children's engagement with environmental protection concepts and encourage active involvement in learning processes (Umarjonovna, 2023).

Studies examining preschool science learning needs indicate that teachers frequently identify life and environmental topics as highly relevant but also challenging to teach effectively without suitable strategies and resources. Addressing these needs requires educational approaches that combine hands-on activities, exploration, and guided interaction to support children's conceptual understanding (Batsaikhan et al., 2026; Ramulumo & Shabalala, 2025; Tasdemir & Yildiz, 2024).

Building on the preceding discussion of early childhood science education and the importance of supporting young children's understanding of life and environmental concepts through active, meaningful experiences, the need for educational strategies that translate these theoretical principles into classroom practice becomes evident. While the literature emphasizes children's agency, inquiry, and hands-on exploration as central to early science learning, these principles require concrete pedagogical frameworks that can be realistically implemented in kindergarten classrooms. In this context, the Learning Stations Strategy emerges as a practical and theoretically grounded approach that aligns with contemporary views of how young children learn scientific concepts through interaction, movement, and guided exploration.

The Learning Stations Strategy is rooted in the philosophy of active, student-centered learning, where learners are viewed as active participants in constructing knowledge rather than passive recipients of information (Atmann et al., 2021). This strategy is based on organizing the learning environment into multiple stations or centers, each offering a specific activity or task related to shared learning objectives. Children rotate between these stations according to a planned structure, engaging with a variety of materials, tasks, and modes of interaction that collectively support concept development (Alsaadi & Sultan, 2021). Such an approach allows learning to unfold through exploration, experimentation, and dialogue, rather than through direct transmission of content.

The Learning Stations Strategy is an educational approach in which the classroom is organized into several structured activity stations. Each station focuses on a specific task or learning objective, and children rotate between stations according to a planned sequence. Rather than receiving information through whole-class teaching, learners actively explore materials, complete hands-on tasks, and engage in guided discussions at each station. Educationally, this strategy is grounded in student-centered and constructivist principles, where knowledge is built through direct interaction with materials and social dialogue (Alsaadi & Sultan, 2021; Eickholt et al., 2020). By offering multiple forms of engagement within a single lesson, learning stations allow children to experience concepts through action, observation, and reflection, which supports deeper conceptual understanding.

In early childhood science education, such stations are intentionally organized to create structured yet flexible environments that guide children's exploration. These characteristics include the following:

Clear and specific learning objective: Each station is organized around a well-defined concept or sub-concept derived from the educational unit. The objective is limited in scope to ensure focused exploration and conceptual clarity for young learners (Ravanis, 2022).

Defined and organized physical space: The station occupies a clearly structured area within the classroom that supports small-group or individual engagement. Its spatial organization reduces distraction and promotes sustained attention, which is essential in early childhood settings (Eickholt et al., 2020).

Carefully selected and developmentally appropriate materials: Materials are intentionally chosen to align with the learning objective and may include manipulatives, visual cards, real-life objects, simple experimental tools, and short inquiry prompts. These resources are designed to encourage observation, comparison, and explanation rather than passive participation (Siry et al., 2023).

Guided inquiry prompts and structured activity sequence: Each station includes brief prompts or guiding questions that structure children's engagement in a logical progression (e.g., observe – compare – explain). This organization supports meaningful interaction with materials and gradual conceptual development (Alsaadi & Sultan, 2021).

Each Learning Station is designed to focus on a specific concept, phenomenon, or a small cluster of closely related ideas within the broader educational unit, rather than attempting to address the entire program simultaneously. This focused structure allows children to engage deeply with manageable conceptual elements and gradually build coherent understanding across stations. By dividing the unit into concept-centered stations, the strategy

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supports incremental conceptual development and aligns with research highlighting the importance of structured, developmentally appropriate science experiences in early childhood (Alsaadi & Sultan, 2021; Siry et al., 2023).

The design of Learning Stations is also informed by awareness of children's prior ideas and potential misconceptions about scientific topics. Activities within each station include guiding questions and exploratory tasks that invite children to express their thinking, compare ideas, and reflect on observations. Through interaction with materials and dialogue with peers and the teacher, children are supported in refining and reorganizing their understanding (Ravanis, 2022; Siry et al., 2023).

Research highlights that learning stations provide a flexible educational framework that accommodates individual differences among learners and supports learning at varying paces. This flexibility is particularly important in early childhood settings, where children differ widely in prior experiences, interests, and developmental readiness (Yonchai et al., 2023). In this regard, learning stations create opportunities for children to engage with content in ways that feel accessible and meaningful to them. Evidence from primary classroom contexts suggests that learning stations enhance student engagement and foster a sense of ownership over learning, as children actively participate in tasks and make simple decisions about how they interact with activities (da Silva, 2024; Eickholt et al., 2020; Fhaim & Abdulraheem, 2025).

Beyond engagement, learning stations have been shown to support important cognitive and self-regulatory processes. Studies indicate that when learners move between stations and encounter tasks that require focus, problem-solving, and reflection, they gradually develop skills related to self-regulated learning. Alsaadi and Sultan (2021) found that learning stations positively influenced academic achievement and self-regulated learning, particularly when students were given structured opportunities to manage their time and activities. In early childhood contexts, this gradual development of autonomy and responsibility lays an important foundation for lifelong learning.

From a pedagogical perspective, learning stations allow for the integration of diverse learning experiences within a single lesson. Hands-on activities, observation tasks, simple experiments, and guided discussions can coexist within the same educational unit, enabling children to encounter concepts through multiple representations. This diversity of experiences helps deepen understanding and supports the construction of more coherent conceptual frameworks. Eickholt et al. (2020) emphasized that station-based learning environments transform teacher-centered classrooms into flexible, active learning spaces that promote meaningful interaction with content rather than surface-level engagement.

The Learning Stations Strategy is particularly suitable for kindergarten children due to its alignment with their developmental characteristics. Young children have a natural need for movement, exploration, and social interaction. They also tend to have relatively short attention spans and benefit from varied, activity-based learning experiences. Rotating between stations allows children to remain physically active while staying cognitively engaged. The structured movement reduces monotony and helps maintain attention, while collaborative activities promote communication and shared thinking (Ravanis, 2022; Siry et al., 2023). In this way, the strategy responds directly to how young children learn best through doing, interacting, and experiencing rather than through passive listening.

The effectiveness of learning stations is further enhanced when activities are organized around structured rotation, which helps maintain children's attention and reduces monotony. Rotating station models provide a balance between variety and structure, allowing children to revisit concepts through different activities while remaining within a clear organizational framework. Yonchai et al. (2023) demonstrated that rotating station models contribute to improved learning outcomes by sustaining engagement and offering repeated opportunities to interact with key ideas from multiple perspectives.

Learning stations also support adaptive learning by allowing activities to be designed at different levels of complexity. When stations are intentionally planned to address varying abilities and learning needs, they can provide appropriate challenges for all learners. Fhaim and Abdulraheem (2025) reported that adaptive learning stations had a positive impact on cognitive achievement, highlighting the value of tailoring activities to learners' capabilities. This aspect is particularly relevant in early childhood science education, where children enter the classroom with diverse prior knowledge and intuitive ideas about scientific phenomena.

In science education, learning stations offer a particularly suitable environment for conceptual development because they emphasize direct experience, observation, and discussion. Rather than encountering scientific concepts as abstract information, children engage with them through concrete activities and materials. Through this process, children test ideas, observe outcomes, and refine their understanding through interaction with peers and teachers. This approach aligns closely with constructivist views of learning, which emphasize that knowledge is actively built through engagement with the learning environment (Al-Zahrani, 2018; Zaki, 2013).

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The use of learning stations also reshapes the role of the teacher in the classroom. Instead of serving primarily as a source of information, the teacher acts as a facilitator who supports learning by guiding exploration, asking open-ended questions, and responding to children's ideas. This shift allows children greater freedom to experiment and express their thinking while still benefiting from intentional guidance. Research suggests that such facilitative roles contribute to deeper and more sustainable learning, as learners are encouraged to reflect, revise their ideas, and build understanding over time (Atmann et al., 2021).

Building on this theoretical groundwork, it is clear that while we champion active, inquiry-based science in early childhood, a vital question remains: how can we best translate these ideals into structured classroom practices that truly nurture a child's conceptual growth? While the "Learning Stations Strategy" is often praised for fostering independence and engagement, there is still a noticeable lack of empirical evidence exploring its specific impact on how kindergarteners grasp concepts of life and the environment. This is especially true within the unique context of early childhood settings, where the bridge between theory and practice is most critical.

The present study addresses this gap by adopting the Learning Stations Strategy as a purposeful educational approach designed to deepen children's understanding of the natural world. By immersing learners in a rich, activity-based environment-one that prioritizes exploration, careful observation, and guided discovery-this strategy speaks directly to the natural way young children learn. Ultimately, this research strives to show that learning stations can do more than just keep children "busy" or "engaged"; they can be a powerful vehicle for the systematic development of foundational scientific concepts, offering valuable insights for both researchers and educators dedicated to the early years.

Despite the recognized importance of active and inquiry-based approaches in early childhood science education, limited empirical evidence exists regarding the effectiveness of the Learning Stations Strategy in developing young children's understanding of life and environmental concepts. Addressing this gap, the present study aims to examine the impact of the Learning Stations Strategy on developing kindergarten children's scientific concepts of life and environment. The study therefore sought to answer the following research questions.

Research Questions

- What scientific concepts of life and environment are appropriate for kindergarten children at level three?
- What is the impact of the Learning Stations Strategy on developing kindergarten children's scientific concepts of life compared to a teacher-centered teaching approach?
- What is the impact of the Learning Stations Strategy on developing kindergarten children's scientific concepts of the environment compared to a teacher-centered teaching approach?
- Are there statistically significant differences between the experimental and control groups in the post-test scores of scientific concepts of life and environment attributable to the Learning Stations Strategy?
- What is the magnitude of the effect (effect size) of the Learning Stations Strategy on kindergarten children's overall scientific concepts of life and environment?

Research Methodology

Design

This study adopted a quasi-experimental research design, which is widely used in educational research when random assignment of participants is not feasible, particularly in early childhood educational settings. The design involved two groups: an experimental group and a control group, both of which were exposed to the same educational content through a unified science educational unit. The experimental group was taught using the Learning Stations Strategy, while the control group was taught the same unit using a teacher-centered approach commonly applied in kindergarten science activities, which typically involves teacher-led explanation, whole-class activities, and the use of pictures and guided questioning. This design allowed the study to isolate the effect of the educational strategy while controlling for content, learning objectives, and instructional time. A pre-test–post-test design was employed for both groups to assess changes in children's understanding of scientific concepts of life and environment. The Scientific Concepts Test of Life and Environment was administered before the intervention to establish baseline equivalence between the groups and again after the completion of the educational unit to measure learning outcomes.

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The quasi-experimental design was especially suitable for this study because of the nature of early childhood settings. In kindergarten classrooms, children benefit from stable routines and familiar group structures that support their sense of comfort and security. For this reason, it is not always practical or appropriate to reorganize children into entirely new groups for research purposes. By working with intact classroom groups and applying different educational approaches, the study was able to examine the impact of the strategy in a natural and developmentally appropriate way. This design allowed the research to remain both methodologically sound and respectful of young children's learning environment.

Table 1 summarizes the experimental design of the study, including the educational approaches applied to the experimental and control groups.

Table 1
Study Design Overview

Component	Experimental Group	Control Group
Purpose	Receive the educational unit through the Learning Stations Strategy	Receive the same educational unit using a teacher-centered approach (no learning stations)
Educational content	The same science unit (Life & Environment concepts)	The same science unit (Life & Environment concepts)
Teaching approach (independent variable)	Learning Stations Strategy (station-based activities)	Teacher-centered whole-class approach (no learning stations)
Experimental treatment	Station rotation with hands-on tasks, simple experiments, observation activities, and guided discussions	Teacher explanation, whole-class activities, and guided questioning aligned with the unit content
Setting	Kindergarten classroom	Kindergarten classroom
Measurement points	Pre-test and post-test	Pre-test and post-test
Instrument	Scientific Concepts Test of Life and Environment	Scientific Concepts Test of Life and Environment

Participants

The participants of the study consisted of 64 kindergarten children enrolled in level three at a public kindergarten in Hofuf, Al-Ahsa, Saudi Arabia. Participants were selected using simple random sampling. The sample included both boys and girls, with 33 boys and 31 girls. Children's names were first listed and assigned numerical codes, after which a random selection procedure was used to identify the study sample. The selected children were then randomly assigned equally to two groups: an experimental group and a control group, with 32 children in each group. The mean age of the participating children was approximately 5.5 years, which is consistent with the typical age range for kindergarten level three. The use of random selection and equal random assignment helped ensure comparability between the two groups prior to the intervention, thereby supporting the internal validity of the study. All participating children were typically developing and regularly attending kindergarten during the implementation period. The study was conducted within the regular classroom setting to maintain a familiar and supportive learning environment.

The selected kindergarten represents a typical public early childhood educational setting in Al-Ahsa, Saudi Arabia. It follows the national kindergarten curriculum and operates under standard regulations of the Ministry of Education. The classroom structure, daily schedule, and teaching practices are consistent with those commonly found in public kindergartens across the region. Therefore, the setting can be considered reasonably representative of similar early childhood educational environments.

Data Collection and Analysis

Data were collected using the Scientific Concepts Test of Life and Environment, which was administered to both the experimental and control groups before and after the implementation of the educational unit. The pre-test was used to assess children's initial understanding of scientific concepts of life and environment and to ensure equivalence between the two groups prior to the intervention. Following the completion of the educational unit, the same test was administered as a post-test under identical conditions.

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All test administrations were conducted individually in a quiet and familiar setting to ensure that children were comfortable and able to respond without distraction. Children's responses were recorded systematically, and total scores as well as domain-specific scores (Life Concepts and Environmental Concepts) were calculated for each participant.

For data analysis, descriptive statistics were first computed, including means and standard deviations, to provide an overview of children's performance in the pre-test and post-test for both groups. To examine differences between the experimental and control groups, inferential statistical analyses were conducted. Appropriate statistical tests were selected to compare post-test scores while accounting for pre-test performance.

In addition to testing for statistical significance, effect size measures were calculated to determine the magnitude of the impact of the Learning Stations Strategy on children's scientific concept development. Effect size analysis was included to provide a clearer understanding of the practical significance of the findings, beyond statistical differences alone.

The level of statistical significance was set at $p \leq .05$. Data analysis procedures were carried out using suitable statistical software, and the results were interpreted in light of the study's research questions and objectives**.**

Instruments

Scientific Concepts of Life and Environment List

The first instrument of the study was the Scientific Concepts of Life and Environment List, which was developed to identify the scientific concepts appropriate for kindergarten children and to serve as a foundation for the educational unit, learning stations strategy, and assessment tools used in the study.

The development of this list began with a comprehensive review of relevant literature and previous studies related to early childhood science education, life science concepts, and environmental education (e.g., Delserieys & Kampeza, 2025; Larimore, 2020; Ravanis, 2022; Siry et al., 2023). This review aimed to identify scientific concepts that are developmentally appropriate for young children and aligned with the core goals of early childhood science education, particularly those emphasizing inquiry, active engagement, and meaningful interaction with the natural environment (Raven & Wenner, 2023; Tasdemir & Yildiz, 2024). In addition, studies focusing on life and environmental concepts in early childhood were examined to ensure that the selected concepts reflect children's everyday experiences and support the development of early scientific understanding and environmental awareness (Acharibasam & McVittie, 2023; Priadi & Fatria, 2024; Ramulumo & Shabalala, 2025).

Based on this review, the initial version of the list was constructed. The preliminary list consisted of two main axes, with five sub-concepts under each axis. The list was organized into two main sections: Life Concepts and Environmental Concepts, reflecting the core domains of scientific understanding targeted in the study.

The Life Concepts axis focused on helping children understand living things through direct observation, simple activities, and everyday experiences. It included concepts related to distinguishing between living and non-living things, identifying the basic needs of living organisms, recognizing growth and change in living things, understanding the simple functions of their parts, and appreciating the diversity of living organisms.

The Environmental Concepts axis aimed to develop children's awareness of their surrounding environment and their relationship with natural resources. This axis included concepts related to the natural components of the environment, everyday uses of natural resources, the relationship between living things and their environment, caring for the environment, and recognizing simple forms of environmental pollution.

The initial version of the list was then submitted to a panel of experts in early childhood education and science education methods. The experts were asked to review the list in terms of clarity, relevance, scientific accuracy, and developmental appropriateness for kindergarten children. Their feedback was carefully analyzed and used to refine the list by revising wording, removing unsuitable items, and ensuring conceptual clarity.

Based on the experts' evaluations, the final version of the Scientific Concepts of Life and Environment List was approved and adopted for use in the study. The validated list of concepts is presented in Table 2, organized according to the two main axes and their corresponding sub-concepts.

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Table 2
Scientific Concepts of Life and Environment for Kindergarten Children

Main Axis	Sub-Concepts
Life Concepts	a. Living and non-living things: distinguishing between living and non-living objects in the surrounding environment. b. Basic needs of living things: recognizing the need for water, air, food, and light for living organisms. c. Growth and change in living things: understanding that plants grow and change over time. d. Parts of living things and their simple functions: identifying main parts of plants, visible animal body parts, and their basic functions. e. Diversity of living things: recognizing different types of animals and simple ways they move and obtain food.
Environmental Concepts	a. Natural components of the environment: identifying water, air, soil, and sunlight as basic environmental elements. b. Uses of natural resources: recognizing everyday uses of water, air, and sunlight. c. Living things and their environment: understanding that living things live in specific places and depend on their environment to survive. d. Caring for the environment: practicing simple behaviors such as keeping the environment clean, saving water, and reusing materials. e. Simple environmental pollution: identifying nearby sources of pollution and recognizing their basic effects on living things.

Scientific Concepts Test of Life and Environment

The second instrument of the study was the Scientific Concepts Test of Life and Environment, developed to assess kindergarten children's understanding of the targeted concepts before and after the intervention.

Test Format and Rationale: Considering the developmental characteristics of kindergarten children, especially their emerging literacy skills and limited ability to read written items independently, the test was designed as a picture-based, orally administered test. In practice, the examiner presented each item using clear visual stimuli (pictures) and read the question aloud in simple language. Children responded by choosing the correct picture, pointing, or giving a short verbal answer when appropriate. This format helped ensure that the test measured concept understanding rather than reading ability, and it reduced anxiety while keeping the assessment engaging and age-appropriate. For example, a child might be shown three pictures (a tree, a rock, and a car) and asked, "Which one is a living thing?" In another item, the child might see pictures of a clean park and a polluted area and be asked, "Which place is better for living things?"

Test Content and Structure: The test was constructed based on the validated Scientific Concepts of Life and Environment List (Table 2). Accordingly, the test covered two main domains:

Life Concepts (five sub-concepts): living vs. non-living things; basic needs of living things; growth and change; parts of living things and their simple functions; diversity of living things.

Environmental Concepts (five sub-concepts): natural components of the environment; uses of natural resources; living things and their environment; caring for the environment; simple environmental pollution.

Items were distributed across the two domains to ensure balanced coverage of the concepts. The test instructions and items were phrased in simple, child-friendly language, and the pictures were selected to be culturally familiar and easy to interpret.

Scoring: Each item was scored dichotomously: 1 for a correct response and 0 for an incorrect response. Total scores and domain scores (Life Concepts and Environmental Concepts) were calculated for analysis.

Validity Evidence: Content validity was established through expert review. A panel of specialists in early childhood education and science education methods examined the test items, pictures, and instructions for clarity, relevance, scientific accuracy, and developmental appropriateness. Based on their feedback, several refinements were made (e.g., simplifying wording, replacing ambiguous pictures, and revising items that could be misunderstood).

Pilot Testing and Reliability: To check the clarity and feasibility of administration, the test was piloted with an exploratory sample of 20 kindergarten children who were not included in the main study sample. The pilot administration helped confirm that children understood the questions and could respond appropriately to the picture-based items within a reasonable time.

Reliability: The reliability of the Scientific Concepts Test of Life and Environment was examined using Cronbach's alpha coefficient. The test was administered to a pilot sample of 20 kindergarten children who were not included

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in the main study sample. Cronbach's alpha was calculated for each domain of the test as well as for the test as a whole. The results indicated satisfactory levels of internal consistency, as shown below:

- Life Concepts domain: Cronbach's alpha = .82
- Environmental Concepts domain: Cronbach's alpha = .79
- Total test: Cronbach's alpha = .85

These coefficients indicate acceptable to good reliability for research purposes in early childhood education. In addition, item-level analysis based on the pilot data was conducted to examine item clarity and discrimination. Minor revisions were made to items that showed ambiguity or weak performance before administering the test to the main study sample.

The Scientific Concepts Test of Life and Environment was administered individually to each child within the kindergarten. Individual administration was used to minimize peer influence during the assessment. During the test, the items were presented orally, and children were guided through the picture-based questions using clear and simple instructions. The same standardized administration procedures were applied to all participants during both the pre-test and post-test to ensure consistency of administration.

Group Equivalence (Pre-test Results)

Before implementing the educational unit, group equivalence was examined through the pre-test administration of the Scientific Concepts Test of Life and Environment. This step aimed to ensure that there were no statistically meaningful differences between the experimental and control groups prior to the intervention.

The test covered two main axes: Life Concepts and Environmental Concepts, each consisting of five sub-domains. The sub-domains differed in their maximum possible scores to reflect variations in conceptual complexity and number of items within each domain. Descriptive statistics, including means and standard deviations, were calculated for both groups across all domains.

The pre-test results indicated that the experimental and control groups were comparable in their overall performance as well as across all sub-domains, suggesting an acceptable level of equivalence prior to the implementation of the Learning Stations Strategy. Tables 3 and 4 present the descriptive statistics of the pre-test results of the Scientific Concepts of Life and Environment test, aiming to examine the equivalence of the experimental and control groups across the main axes and sub-domains prior to the implementation of the Learning Stations Strategy.

Table 3

Pre-test Descriptive Statistics for Life Concepts (Group Equivalence)

Sub-Concept	Max Score	Experimental Group *M (SD)*	Control Group *M (SD)*
Living and non-living things	17	7.42 (2.11)	7.35 (2.04)
Basic needs of living things	18	8.63 (2.48)	8.51 (2.39)
Growth and change in living things	14	6.12 (1.87)	6.08 (1.91)
Parts of living things and their functions	20	9.54 (2.76)	9.61 (2.69)
Diversity of living things	12	5.21 (1.66)	5.18 (1.59)

Table 4

Pre-test Descriptive Statistics for Environmental Concepts (Group Equivalence)

Sub-Concept	Max Score	Experimental Group *M (SD)*	Control Group *M (SD)*
Natural components of the environment	15	7.88 (2.05)	7.91 (2.12)
Uses of natural resources	14	6.47 (1.94)	6.39 (1.88)
Living things and their environment	18	8.02 (2.31)	7.96 (2.28)

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Sub-Concept	Max Score	Experimental Group *M (SD)*	Control Group *M (SD)*
Caring for the environment	12	5.68 (1.53)	5.71 (1.49)
Simple environmental pollution	10	4.11 (1.27)	4.08 (1.22)

The descriptive statistics of the pre-test showed close mean scores and comparable standard deviations between the experimental and control groups across all sub-concepts. These results indicate that the two groups were equivalent in their initial understanding of scientific concepts of life and environment prior to the intervention, supporting the internal validity of the study.

Procedures: Implementation of the Learning Stations Strategy

The study procedures were implemented using a carefully designed science educational unit focusing on scientific concepts of life and environment. The same instructional unit was taught to both the experimental and control groups to ensure equivalence of content, objectives, and learning outcomes. The difference between the two groups lay in the educational strategy used during implementation.

Preparation Phase: Before the intervention, the educational unit was developed based on the validated Scientific Concepts of Life and Environment List. The unit included clearly defined objectives, learning activities, visual materials, and assessment tasks appropriate for kindergarten children. The classroom environment was prepared in advance, and all materials needed for implementing the unit were made available.

Implementation with the Experimental Group: The educational unit was implemented with the experimental group using the Learning Stations Strategy. The classroom was organized into five structured learning stations during each session. The stations included hands-on activities, simple experiments, picture-based observation tasks, and guided discussion prompts.

Children rotated between the stations individually or in small groups according to a planned schedule. During this process, children actively explored the learning materials, observed phenomena, and shared their ideas. The teacher's role was to facilitate learning by guiding children, asking open-ended questions, and providing support when needed, without directly presenting information.

During implementation, children worked individually or in small groups as they rotated between stations. They were encouraged to observe materials, manipulate objects, discuss ideas with peers, and respond to guiding questions. The teacher's role was primarily facilitative: providing brief instructions, asking open-ended questions, monitoring engagement, and offering scaffolding when needed. Rather than delivering direct explanations, the teacher supported children in constructing understanding through interaction and reflection.

Implementation with the Control Group: The same educational unit was implemented with the control group using a teacher-centered teaching approach commonly applied in kindergarten science activities. Instruction was delivered through whole-class teaching, teacher explanations, and guided questioning, without the use of learning stations or station-based activities. Children received the same content and concepts but through direct instruction and collective classroom activities.

In the control group, children participated in whole-class activities led by the teacher. The teacher presented the concepts through explanation, questioning, and visual aids, while children listened, responded to directed questions, and completed structured tasks. Interaction was primarily teacher-directed, with fewer opportunities for small-group exploration or independent manipulation of materials.

Post-Implementation Phase: After completing the educational unit, the Scientific Concepts Test of Life and Environment was administered to both groups as a post-test using the same procedures applied in the pre-test. This allowed for a fair comparison of learning outcomes and for examining the impact of the Learning Stations Strategy, independent of content differences, on developing scientific concepts of life and environment.

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board (IRB) at Princess Nourah bint Abdulrahman University under IRB Log Number: 26-0123. All research procedures were conducted in accordance with the regulations of the Kingdom of Saudi Arabia, the policies and procedures of the PNU Institutional Review

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Board, and in compliance with the principles of the Declaration of Helsinki. Participation in the study was voluntary, and informed consent was obtained from parents or legal guardians prior to children's participation. The learning station activities were age-appropriate, educational in nature, and aligned with the early childhood curriculum. Children were not exposed to any physical or psychological risks, and no personal identifying information was collected. Strict measures were taken to ensure confidentiality, anonymity, and the secure handling of all data.

Research Results

Development of Life Concepts

Tables 5 and 6 present the pre- and post-test results for the Life Concepts domain for the control and experimental groups, respectively. The tables illustrate changes in children's performance across the life concept sub-domains, along with the corresponding statistical significance and effect size values.

Table 5
Pre- and Post-Test Results for Life Concepts – Control Group

Life Concepts Sub-Concept	Max Score	Pre-Test *M (SD)*	Post-Test *M (SD)*	*t* value	*p*	Effect Size (η^2)	Effect Level
Living and non-living things	17	7.35 (2.04)	8.12 (2.01)	1.84	.071	.05	Small
Basic needs of living things	18	8.51 (2.39)	9.24 (2.31)	1.67	.101	.04	Small
Growth and change in living things	14	6.08 (1.91)	6.74 (1.85)	1.58	.119	.04	Small
Parts of living things and functions	20	9.61 (2.69)	10.42 (2.63)	1.73	.089	.05	Small
Diversity of living things	12	5.18 (1.59)	5.86 (1.55)	1.61	.112	0.04	Small
Total Life Concepts	**81**	**36.73 (6.22)**	**40.38 (6.04)**	**1.92**	**.060**	**.06**	**Small**

The results in Table 5 indicate a slight improvement in post-test scores for the control group across all life concept sub-domains. However, the observed differences were not statistically significant at the .05 level, and effect size values were small, suggesting that the teacher-centered teaching approach had a limited impact on the development of life concepts.

Table 6
Pre- and Post-Test Results for Life Concepts – Experimental Group

Life Concepts Sub-Concept	Max Score	Pre-Test *M (SD)*	Post-Test *M (SD)*	*t* value	*p*	Effect Size (η^2)	Effect Level
Living and non-living things	17	7.42 (2.11)	13.86 (1.72)	11.94	.001	.82	Large
Basic needs of living things	18	8.63 (2.48)	15.21 (1.83)	12.37	.001	.83	Large
Growth and change in living things	14	6.12 (1.87)	11.48 (1.54)	11.06	.001	.80	Large
Parts of living things and functions	20	9.54 (2.76)	16.92 (1.96)	12.81	.001	.84	Large
Diversity of living things	12	5.21 (1.66)	10.37 (1.41)	10.98	.001	.79	Large
Total Life Concepts	**81**	**36.92 (6.41)**	**67.84 (5.12)**	**14.26**	**.001**	**.86**	**Large**

The results in Table 6 reveal statistically significant differences between pre- and post-test scores for the experimental group across all life concept sub-domains in favor of the post-test. The obtained t values were high and statistically significant at the .001 level, accompanied by large effect sizes, indicating a strong impact of the Learning Stations Strategy on developing kindergarten children's scientific concepts of life.

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When comparing the performance of both groups, the experimental group demonstrated substantially greater gains in life concepts than the control group. While children taught through the conventional teaching approach showed only marginal improvement, those exposed to the Learning Stations Strategy achieved marked progress across all sub-concepts. This pattern suggests that learning stations provided a rich, interactive learning environment that enabled children to actively explore, observe, and construct scientific understanding in a developmentally appropriate manner.

Development of Environmental Concepts

Tables 7 and 8 present the pre- and post-test results for the Environmental Concepts domain for the control and experimental groups, respectively. The tables summarize changes in children's performance across environmental concept sub-domains, along with the associated statistical significance and effect size values.

Table 7
Pre- and Post-Test Results for Environmental Concepts – Control Group

Environmental Concepts Sub-Concept	Max Score	Pre-Test *M (SD)*	Post-Test *M (SD)*	*t* value	*p*	Effect Size (η^2)	Effect Level
Natural components of the environment	15	7.91 (2.12)	8.54 (2.06)	1.52	.134	.04	Small
Uses of natural resources	14	6.39 (1.88)	7.02 (1.81)	1.49	.141	.04	Small
Living things and their environment	18	7.96 (2.28)	8.63 (2.21)	1.57	.121	.04	Small
Caring for the environment	12	5.71 (1.49)	6.28 (1.46)	1.46	.149	.04	Small
Simple environmental pollution	10	4.08 (1.22)	4.61 (1.18)	1.43	.158	.04	Small
Total Environmental Concepts	**69**	**32.05 (5.63)**	**35.08 (5.47)**	**1.68**	**.098**	**.05**	**Small**

The control group showed slight improvement in post-test scores across all environmental concept sub-domains. However, these differences were not statistically significant, and the effect sizes were small, indicating a limited impact of the teacher-centered teaching approach on environmental concept development.

Table 8
Pre- and Post-Test Results for Environmental Concepts – Experimental Group (Learning Stations Strategy)

Environmental Concepts Sub-Concept	Max Score	Pre-Test *M (SD)*	Post-Test *M (SD)*	*t* value	*p*	Effect Size (η^2)	Effect Level
Natural components of the environment	15	7.88 (2.05)	13.24 (1.61)	11.32	.001	.80	Large
Uses of natural resources	14	6.47 (1.94)	12.18 (1.52)	11.87	.001	.82	Large
Living things and their environment	18	8.02 (2.31)	15.36 (1.74)	12.41	.001	.83	Large
Caring for the environment	12	5.68 (1.53)	10.64 (1.28)	11.09	.001	.79	Large
Simple environmental pollution	10	4.11 (1.27)	8.72 (1.06)	10.96	.001	.78	Large
Total Environmental Concepts	**69**	**32.16 (5.78)**	**60.14 (4.83)**	**13.92**	**.001**	**.85**	**Large**

The results indicate statistically significant improvements in post-test scores for the experimental group across all environmental concept sub-domains. High t values and large effect sizes demonstrate a strong impact of the Learning Stations Strategy on developing kindergarten children's environmental concepts.

A clear contrast emerged between the two groups. While the control group exhibited minimal gains, the experimental group achieved substantial improvements across all environmental sub-concepts. These findings suggest that the Learning Stations Strategy provided meaningful, activity-based experiences that effectively supported children's understanding of environmental concepts.

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Discussion

The findings regarding life concepts reveal a clear advantage for children in the experimental group. Those who were taught using the Learning Stations Strategy showed greater progress than their peers in the control group, who were taught using a teacher-centered approach. While the control group's improvement remained limited and statistically stagnant, the experimental group achieved substantial breakthroughs across every sub-domain of life concepts. The presence of large effect sizes further confirms that these gains were far from accidental; instead, they represent a direct and powerful testament to the impact of the Learning Stations Strategy and the purposeful learning experiences it fostered.

One key factor that helps explain these results is the nature of the Learning Stations Strategy itself. Learning stations offer children repeated opportunities to interact with scientific ideas through hands-on activities, observation, and guided exploration. In the context of life concepts, such as distinguishing between living and non-living things or understanding the basic needs of living organisms, children benefit greatly from concrete experiences rather than abstract explanations. The station-based activities allowed children to see, touch, compare, and discuss real examples, which likely supported deeper conceptual understanding. This interpretation aligns with contemporary perspectives in early childhood science education that emphasize learning through direct engagement with materials and phenomena (Larimore, 2020; Raven & Wenner, 2023).

In addition to the educational strategy, the design of the learning unit itself appears to have played an important role in supporting children's learning. The unit was built around carefully selected life concepts that are developmentally appropriate for kindergarten children and closely connected to their everyday experiences. Activities focusing on plant growth, animal diversity, and the basic functions of living things enabled children to link new scientific ideas to familiar contexts. Such connections are known to facilitate concept formation in early childhood, as young learners tend to build understanding by integrating new information with prior experiences (Delserieys & Kampeza, 2025; Ravanis, 2022).

The strong improvement observed in sub-concepts related to growth and change in living things and the parts and functions of living organisms may be attributed to the exploratory and sequential nature of the learning stations. Through rotating between stations, children encountered the same concepts in different forms, such as visual observation, simple experiments, and guided discussion. This repeated exposure from multiple perspectives likely reinforced children's understanding and helped them refine their initial ideas. Previous research has emphasized that young children benefit from revisiting scientific concepts through varied activities rather than encountering them once in a single instructional format (Siry et al., 2023).

Another important aspect is the role of the teacher within the learning stations. Rather than delivering information directly, the teacher acted as a facilitator who guided children's exploration, asked open-ended questions, and encouraged dialogue among peers. This supportive role may have helped children articulate their observations and reflect on their thinking, which is essential for conceptual development. Studies focusing on children's agency in science learning highlight that when children are given space to express ideas and test their understanding, they develop more coherent and durable scientific concepts (Henriksson et al., 2024).

The findings of the present study are consistent with previous research that reported positive effects of station-based or activity-centered approaches on children's science learning. For example, Zaki (2013) and Al-Zahrani (2018) found that using scientific stations in teaching science led to significant improvements in students' understanding of scientific concepts and processes. Although these studies were conducted with older students, their conclusions support the idea that station-based learning environments can effectively enhance conceptual understanding when activities are well designed and aligned with learning objectives.

The results indicate that the Learning Stations Strategy, when combined with a well-structured educational unit, provides a rich learning environment that supports the development of life concepts in early childhood. The strategy appears to move beyond surface-level engagement to foster genuine conceptual understanding by allowing children to actively explore, reflect, and construct meaning. This finding reinforces the view that effective early childhood science education requires not only appropriate content but also educational approaches that respect how young children learn and make sense of the world around them.

Overall, the findings suggest that the structured yet flexible nature of the Learning Stations Strategy played a central role in supporting children's conceptual growth. By combining movement, hands-on exploration, and guided dialogue within a rotating structure, the strategy created repeated and meaningful opportunities for children

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to engage deeply with life concepts. This alignment between instructional design and children's developmental characteristics appears to explain the substantial gains observed in the experimental group.

The results related to the development of environmental concepts reveal a clear and consistent pattern favoring the experimental group that learned through the Learning Stations Strategy. While children in the control group demonstrated only slight and statistically non-significant improvement, those in the experimental group achieved substantial gains across all environmental concept sub-domains, supported by large effect sizes. This contrast suggests that the Learning Stations Strategy provided learning conditions that were particularly effective for fostering young children's understanding of environmental concepts.

One important explanation for these findings lies in the experiential nature of environmental learning within the learning stations. Environmental concepts-such as natural components of the environment, caring for the environment, and simple environmental pollution are inherently connected to children's daily lives and surroundings. The learning stations enabled children to engage directly with these concepts through observation, discussion, and simple, meaningful activities. Rather than learning about the environment as an abstract topic, children interacted with concrete examples that reflected real-life situations, which likely enhanced comprehension and retention. This interpretation is consistent with research emphasizing that environmental understanding in early childhood develops most effectively through direct engagement with natural and familiar contexts (Acharibasam & McVittie, 2023; Priadi & Fatria, 2024).

The structure of the learning stations also appears to have supported gradual and cumulative concept development. By rotating between stations, children encountered environmental ideas repeatedly but in different forms, such as identifying natural elements, discussing how living things depend on their environment, or exploring simple causes of pollution. This variety allowed children to revisit the same concepts from multiple perspectives, helping them refine their understanding over time. Previous studies have noted that repeated exposure to environmental concepts through varied activities strengthens children's ability to organize and connect ideas meaningfully (Siry et al., 2023; Tasdemir & Yildiz, 2024).

The impressive growth seen in how children understand environmental care and the basics of pollution isn't just a matter of luck; it likely stems from the active, hands-on heart of the learning stations. By moving beyond theory and inviting children to actually practice responsibility, whether by keeping their surroundings tidy or exploring ways to protect our resources, these activities turned abstract ideas into lived experiences. This shift from "knowing" to "doing" is what makes the understanding so meaningful. These results reinforce the idea that early environmental awareness flourishes best when we use participatory, behavior-focused approaches, allowing young learners to become active participants in protecting their world (Ramulumo & Shabalala, 2025; Umarjonovna, 2023).

Another factor contributing to the effectiveness of the Learning Stations Strategy is the role of social interaction and dialogue. Environmental concepts often involve relationships between living things and their environment, or between human actions and environmental outcomes. The learning stations provided opportunities for children to talk with peers, share observations, and listen to different viewpoints. These interactions may have supported children's ability to articulate their thinking and develop more coherent explanations. Research in early childhood science education highlights that dialogue and shared reflection play a crucial role in helping children make sense of complex ideas, including those related to the environment (Henriksson et al., 2025; Ravanis, 2022).

The teacher's facilitative role within the learning stations further strengthened children's learning. By guiding exploration rather than directing it, the teacher was able to scaffold children's understanding through timely questions and prompts. This approach likely helped children connect their hands-on experiences with emerging environmental concepts, without overwhelming them with formal explanations. Studies focusing on inquiry-oriented and child-centered science instruction suggest that such facilitation is particularly effective in supporting environmental learning in early childhood (Delserieys & Kampeza, 2025; Raven & Wenner, 2023).

The findings of the present study are also consistent with previous research that reported positive effects of interactive and activity-based approaches on environmental concept development. For instance, studies examining outdoor and exploratory learning environments have shown that young children develop stronger environmental awareness and understanding when learning is embedded in meaningful contexts and supported by active engagement (Batsaikhan et al., 2026; El-Aasar et al., 2024). Although the current study was conducted within a classroom setting, the learning stations appeared to replicate many of the benefits associated with experiential and context-rich environmental learning.

Reflecting on these environmental findings, it becomes clear that the Learning Stations Strategy bolstered by a thoughtfully crafted educational unit did more than just teach; it created a sanctuary for learning perfectly tuned to the developmental rhythms of young children. By weaving together hands-on discovery, social connec-

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tion, and gentle guidance, the strategy allowed children to build their understanding of the environment in a way that felt both natural and deeply significant. These results suggest the need to move beyond teacher-centered instruction. Instead, we should embrace approaches that truly immerse children in the world they inhabit, turning the classroom into a space where environmental stewardship begins to take root.

Taken together, these results indicate that the Learning Stations Strategy provided a supportive framework for environmental learning by transforming abstract ideas into concrete and interactive experiences. The rotation between stations, combined with active participation and social interaction, appears to have strengthened children's understanding of environmental relationships and responsibility. This direct connection between instructional structure and learning outcomes helps explain the strong improvements observed in the experimental group.

Conclusion and Implications

This study examined the impact of the Learning Stations Strategy on the development of scientific concepts related to life and the environment among kindergarten children. The findings provide clear evidence that educational environments centered on active, station-based learning can enhance conceptual development more effectively than teacher-centered methods. Throughout the assessment of both life and environmental domains, children in the experimental group demonstrated a substantial advancement in their understanding. This progress was evidenced by statistically significant differences and reinforced by large effect sizes, indicating that the Learning Stations Strategy facilitates a deep seated development of scientific ideas. Rather than merely increasing classroom participation, this approach allows children to refine their conceptual frameworks through hands-on exploration, observation, and guided dialogue. Such experiences are particularly effective because they align with the natural ways young learners construct knowledge through direct interaction and meaningful repetition. The results further highlight that the intentional design of science units is vital for conceptual development. By engaging with age-appropriate content through diverse and interactive stations, children were able to transform their initial perceptions into a more coherent and durable understanding of the natural world. This underlines the necessity of a deliberate alignment between scientific content and the developmental characteristics of early childhood learners. Beyond the immediate data, this research supports the broader movement toward inquiry-based education. It demonstrates that when educators provide structured yet flexible environments for exploration, young children can successfully master scientific concepts that are often perceived as being beyond their cognitive reach.

Limitations

Although the study was carefully designed and produced clear results, several limitations should be considered when interpreting the findings. The study was conducted with a relatively small sample (n = 64) drawn from a single public kindergarten in one city, which may limit the generalizability of the findings to other early childhood settings that differ in context, teaching practices, or educational systems. In addition, the intervention was implemented over a limited period through one educational unit, and the study assessed learning gains immediately after the intervention without including a delayed post-test to examine the long-term retention of the concepts. Furthermore, children's understanding was assessed using an individual picture-based test appropriate for their developmental level; however, this approach may not fully capture how children apply scientific concepts during play or everyday classroom interactions. Finally, the study examined the Learning Stations Strategy as a comprehensive educational approach and did not isolate the effects of specific elements within the stations, such as hands-on activities, peer interaction, or teacher facilitation. Future research could address these issues by using larger and more diverse samples, incorporating delayed assessments, and examining the contribution of individual components of the strategy.

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Declaration of Interest

The authors declare no competing interest.

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